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(54) Improved structural panel

(57) A structural panel (Figure 1) for use for example in bridge decking has spaced steel sheets (2A, 2B) between which are corrugated stiffening members (3A) of glass fibre reinforced plastics material. The stiffening members (3A) are glued to the spaced sheets (2A, 2B). The voids (15) are filled with plastics foam (4). A strong structure results, in which fabrication costs and maintenance costs are reduced, by virtue of the absence of great lengths of fatigue failure-susceptible welds.

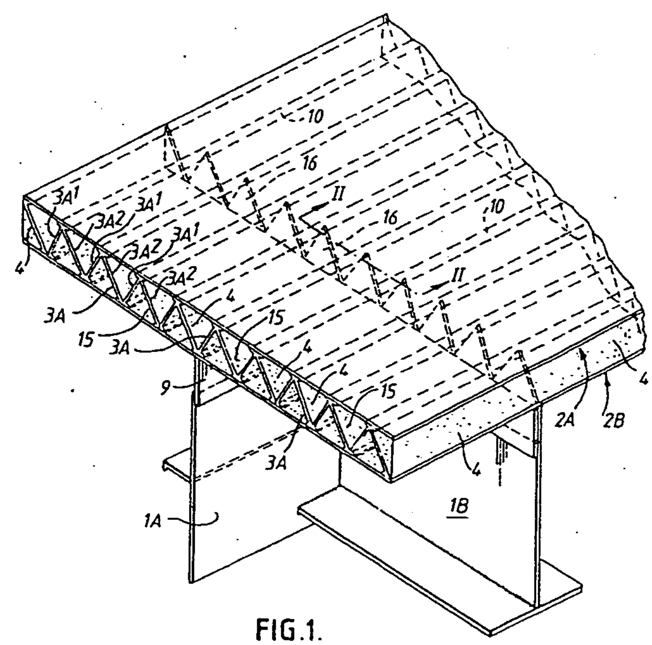

FIG.1.

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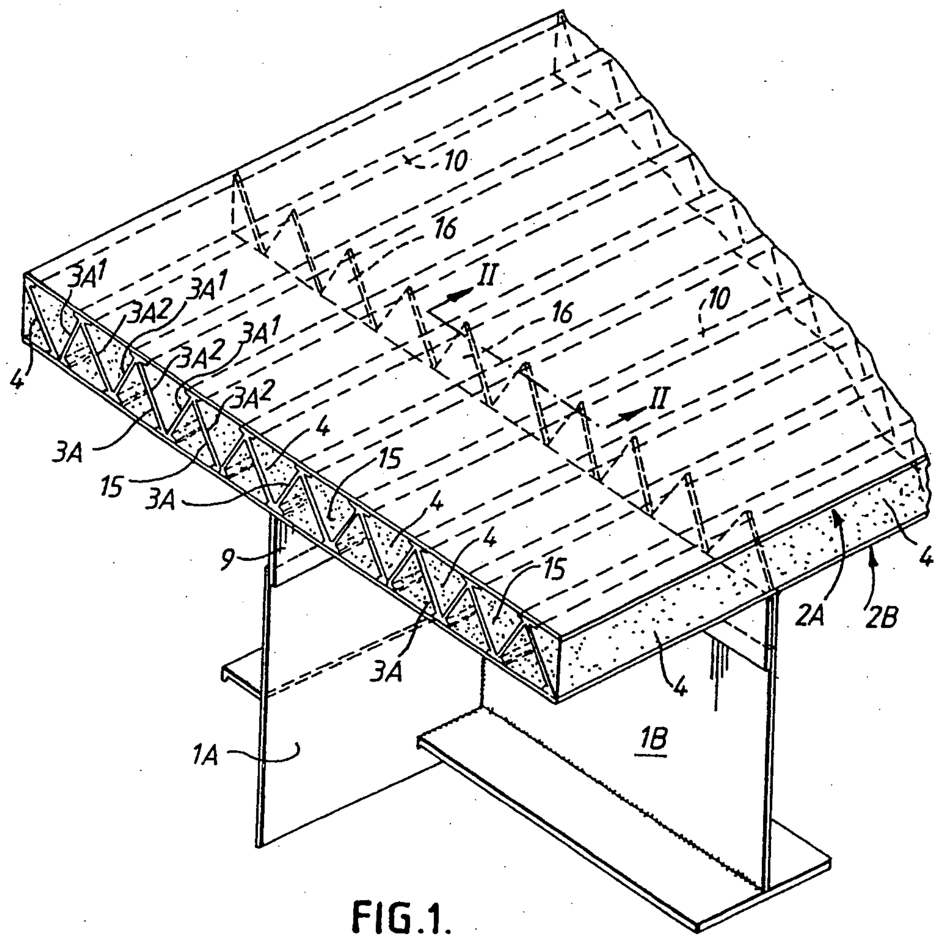
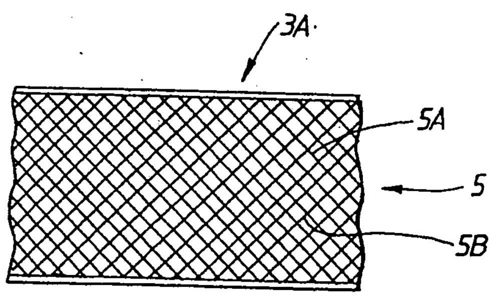


10
16
II
16
10
II
3A1
3A2
3A1
3A1
3A2
3A2
4
3A
15
3A
4
15
4
9
4
15
3A
4
2A
2B
4
1A
1B

FIG.1.



3A
5A
5
5B

FIG.3.

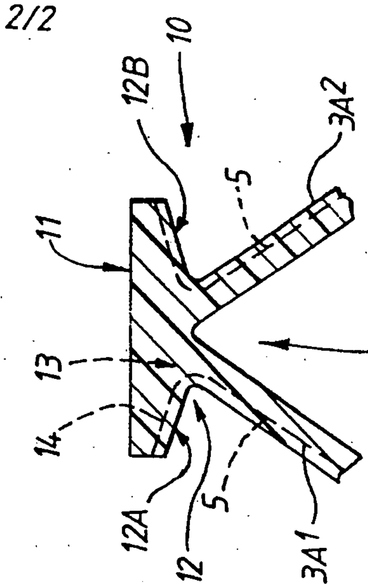


FIG.5.

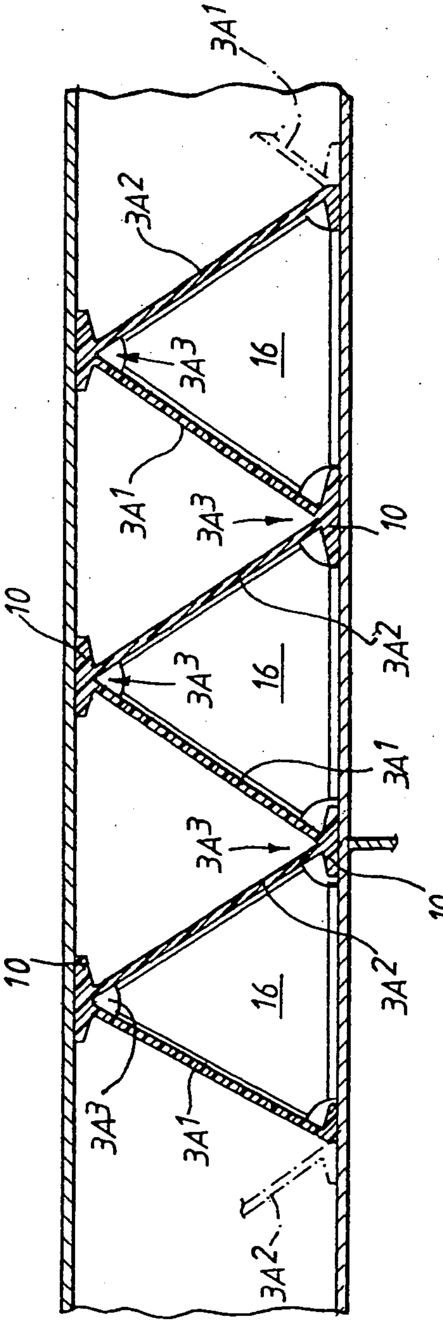


FIG.2.

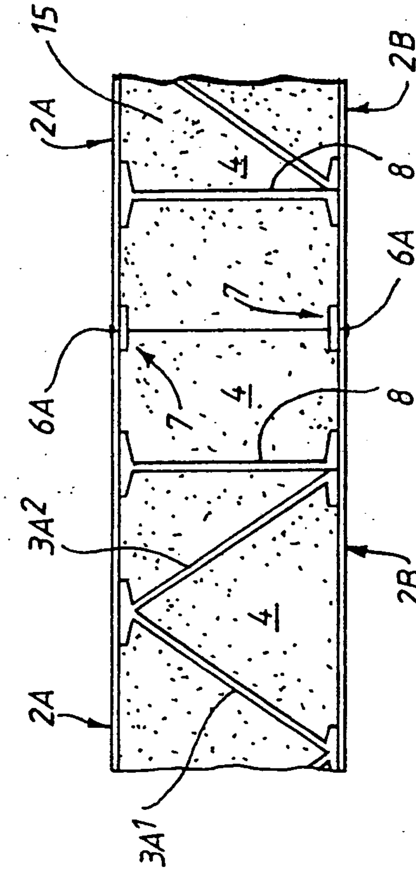


FIG.4.

SPECIFICATION

Improved structural panel

This invention relates to a structural panel, for use as a unit for example in bridge decking or in the floor of a building, and capable of withstanding compressive loading applied transversely to the panel and also loading applied in the general plane of the panel. The panel comprises spaced sheet members and one or more stiffening members between and rigidly fixed to the spaced sheet members. In its preferred form the structural panel is of sandwich construction with elongate stiffening members between and rigidly fixed to flat parallel sheet members.

The structural panel of the invention may be used for instance in bridge decking, floors of buildings, ships' decks and hulls, and car park floors.

Structural panels are known in which a flat sheet steel member is supported on steel ribs, the ribs being connected to the sheet steel member by long welds. This known construction has two main disadvantages: the high cost of fabrication, and the tendency of the long welds to fail in use, leading to high cost of maintenance. The reason for the former is primarily the great amount of skilled welding work involved in welding the numerous decking panels required in for example a road bridge. The reason for weld failure is primarily due to the high flexural stiffness of a steel rib, compared to the low flexural stiffness of the sheet steel member. The sheet steel member flexes over the top of the stiff steel rib, causing eventual weld fatigue failure at points of weld weakness. In maintenance this involves expensive re-welding work.

The problem thus exists of providing a structural panel which is less expensive to make, by avoiding the need for great lengths of expensive welding, and further which avoids weld failures and thus expensive maintenance work. The invention aims to solve this problem and in addition to provide a structural panel which, for a given loading capability, is lighter in weight than known structures.

According to this invention there is provided a structural panel, for use as a unit for example in bridge decking or in the floor of a building, and capable of withstanding loading applied transversely to the panel and also loading applied in the general plane of the panel, and the panel comprising spaced sheet members and at least one elongate stiffening member rigidly fixed to and between the spaced sheet members, characterized in that:— a) the material of which the said at least one elongate stiffening member is made is different from the material of which the spaced sheet members are made; b) the Young's modulus of the said at least one elongate stiffening member is considerably less than the Young's modulus of the spaced sheet members; and c) the said at least one stiffening member is glued, bonded, or otherwise adhered to the spaced sheet members. The spaced sheet members are preferably parallel, and they may be flat or curved. The Young's modulus (E) of the or each elongate stiffening member is preferably not more than half that of the spaced sheet members. The spaced sheet members may be of for example steel, aluminium or prestressed reinforced concrete. The or each elongate stiffening member is made preferably of glass fibre reinforced plastics material, with the fibres arranged cross-wise and also diagonally to the length of the stiffening member. The preferred adhesive is an epoxy resin or a toughened acrylic resin. The plastics material used as the adhesive may be different from the plastics material of which the or each stiffening member is moulded. The stiffening members are preferably moulded by what is known as "pultrusion", that is, the plastics materials with mineral fibre reinforcement is pulled from a forming die of the appropriate shape to give the required cross-section, for example an I-section, for a stiffening member of that cross-sectional shape.

In one embodiment of the invention a sandwich-type panel has I-section glass reinforced plastics stiffening beams adhered top and bottom to spaced parallel flat steel sheets, with stiffening beams extending both lengthwise and transversely. The transverse stiffening beams need only be shear-connected to the lengthwise stiffening beams. The voids defined by the stiffening beams between the flat steel sheets are preferably filled with foamed plastics material, to give additional stiffness and corrosion resistance to the structural panel.

Because the elongate stiffening members are of considerably lower flexural stiffness than the sheet members, stress concentrations are not set up in the sheet members due to the attachment of the stiffening members. In addition the stress distribution across the adhesive connections between the stiffening members and the sheet members can be designed to be as uniform as possible by the use of tapering flanges on the stiffening members and arranging the fibre reinforcement in a particular manner. The tendency for the adhesive connections to fail is therefore reduced as compared with the long welds in known decking panels, and lightweight epoxy resin surfacings can be used.

Preferably the glass or other mineral reinforced plastics, and any foam filling material used, has good fire resistant properties so that where it is necessary to weld adjacent metal sheet members together, this can be done.

An embodiment of the invention will now be described by way of example, with reference to the accompanying drawings, in which:—

Figure 1 is a diagrammatic part-sectional isometric view showing a portion of sandwich-type structural panel and supporting structure;

Figure 2 is an enlarged diagrammatic section taken on the plane II—II of Figure 1;

Figure 3 is a diagrammatic detail elevation of an elongate stiffening member;

Figure 4 is a detail section showing a joint between two panels; and

Figure 5 is a diagrammatic detail section of a flange of a stiffening member.

Referring to Figure 1, there is seen part of a sandwich-type structural panel with part of its supporting structure, the latter including a primary web 1A and a cross girder 1B. The panel comprises two flat, spaced, parallel, steel sheet members 2A, 2B which are glued by an epoxy resin or by a toughened acrylic resin to a series of elongate stiffening members 3A extending in the longitudinal direction as shown. In Figure 1 three stiffening members 3A are seen. Each of these three elongate stiffening members 3A is a unitary moulded structure made up (Figures 1 and 2) of, in effect, three pairs of strips $3A^1$, $3A^2$ of glass fibre reinforced plastics material, with adjacent strips $3A^1$, $3A^2$ being disposed at an angle to one another. Thus the stiffening member 3A is of V-corrugated cross-section with strips $3A^1$, $3A^2$ connected at the apices $3A^3$ of the vees. Each such stiffening member is moulded as a single unitary structure. At the apices $3A^3$ are flanges 10, seen in Figure 5, which will be described in more detail below.

Although the preferred form of elongate stiffening member 3A is as shown and as described above, other elongate members of moulded, reinforced plastics material could be used.

Since the sheet members 2A, 2B are of steel and the elongate stiffening members 3A are of moulded glass fibre reinforced plastics material, it will be understood that they are of different materials and have a different Young's modulus, that of the plastics members 3A being very much less than that of the steel members 2A and 2B.

Other materials can be used, but the material of the sheet members must be different from that of the stiffening members, and the Young's modulus of the stiffening members must be considerably less than that of the sheet members and preferably at least 50% less.

Figure 5 is a diagrammatic detail section of a flange 10. The flanges 10 are integral with the strips $3A^1$ and $3A^2$ of the stiffening member at each apex $3A^3$. The flange 10 is tapered as shown and has an upper surface 11 and a lower surface 12. The upper surface 11 is flat and is adhered to the sheet member 2A by adhesive. The lower surface 12 is in two parts 12A, 12B, each lying in a plane which is inclined to the plane of the upper surface 11. The glass fibre reinforcement 5 of the strips $3A^1$, $3A^2$ extends up into the flange 10 and is bent round as seen at 13 in Figure 5, so that the portion 14 of the reinforcement lies closer to the surface 12 than to the surface 11. By this means the stress distribution across the adhesive connection between a flange surface 11 and a sheet member 2A, 2B can be made uniform. The tendency of the adhesive connection to fail is in this way kept low, and a light-weight epoxy resin surface covering (not shown) can be used on the top of the sheet member 2A.

The voids or compartments 15 formed between the sheet members 2A, 2B and the strips $3A^1$, $3A^2$ are filled with fire-resistant expanded foam 4.

Referring to Figures 1 and 2, glass fibre reinforced plastics diaphragms 16, of generally triangular shape, are fitted in the voids 15 over the cross girder 1B.

The preferred arrangement of glass fibre reinforcement 5 is seen in Figure 3, with fibres 5A, 5B laid crosswise in the plastics material and also diagonally to the length of the stiffening member 3A. This arrangement of the fibres gives good shear strength and stiffness with low axial stiffness. In this way shear deflection is kept low, as is the variation in field stress in the sheet members 2A, 2B caused by the stiffening members 3A being adhered to them.

Figure 4 shows a welded connection between adjacent panels, with sheet members 2A, 2A, and 2B, 2B being butt welded together along seam lines 6A, 6B. The welds are backed by metal strips 7. The edge of each panel is sealed by a strip 8 of glass reinforced plastics material. The void between the strips 8 and strips 7 is also filled with plastics foam 4, after the panels have been welded together at 6A, 6B.

In the present embodiment, disclosed by way of example, the top and bottom faces of the panel are 200 mm apart; the upper sheet member 2A is of steel 8 mm thick and the lower sheet member 2B of steel 6 mm thick.

The stiffening members 3A are formed by the pultrusion method referred to above.

One possible method of fabrication of the structure shown in Figure 1 is as follows.

i) Connecting flats 9 of the primary web 1A and cross girder 1B are welded to the underside of the lower sheet member 2B.

ii) The upper sheet member 2A is placed upside down on a flat bed (or on a curved bed if camber is required) and the stiffening members 3A are glued down on to the member 2A, at the appropriate spacings.

iii) Resin adhesive is applied to the free flange surfaces 11 of the stiffening members. The lower sheet member 2B is lifted and placed accurately on the surfaces 11; it is then pushed down firmly by means of rams applied at the locations of the stiffening members, at the same time being heated to cure the resin adhesive. Finally, the plastics foam material 4 is pumped to fill the voids 15.

The above-described embodiment of structural panel in accordance with the invention is primarily intended for use as a vehicle-supporting surface, for example a bridge deck. But the panel of the invention can have many other applications: one example is the use of a sandwich-type panel to form the bottom flange of a box girder; in this case the plastics stiffening members would be reinforced by a longitudinally arranged fibre reinforcement rather than the diagonally arranged

fibre reinforcement described above. Another example is the use of a sandwich-type panel deck in which the two sheet members are aluminium plates: such a deck is very light in weight and can be used for example in a temporary military bridge. A further example is the use of a sandwich-type panel in which the two sheet members are prestressed concrete slabs: such a panel can be for example a floor in a building.

Claims

1. A structural panel, for use as a unit for example in bridge decking or in the floor of a building, and capable of withstanding loading applied transversely to the panel and also loading applied in the general plane of the panel, and the panel comprising spaced sheet members and at least one elongate stiffening member rigidly fixed to and between the spaced sheet members, characterized in that:—
   a) the material of which the said at least one elongate stiffening member is made is different from the material of which the spaced sheet members are made;
   b) the Young's modulus of the said at least one elongate stiffening member is considerably less than the Young's modulus of the spaced sheet members; and
   c) the said at least one stiffening member is glued, bonded, or otherwise adhered to the spaced sheet members.
2. A panel according to claim 1, characterized in that the spaced sheet members are parallel.
3. A panel according to claim 1, characterized in that the spaced sheet members are flat.
4. A panel according to claim 1 characterized in that the Young's modulus of the said at least one elongate stiffening member is not more than 50% of the Young's modulus of the spaced sheet members.
5. A panel according to claim 1 characterized in that the material of the spaced sheet members is steel or aluminium or prestressed reinforced concrete.
6. A panel according to claim 1 characterized in that the material of the said at least one elongate stiffening member is mineral fibre reinforced plastics material.
7. A panel according to claim 6 characterized in that the mineral fibre reinforcement comprises glass fibres arranged crosswise and also diagonally to the length of the stiffening member.
8. A panel according to claim 1 characterized in that the said at least one elongate stiffening member comprises two or more strips of mineral fibre reinforced plastics material, adjacent strips being disposed at an angle to one another.
9. A panel according to claim 8 characterized in that the or each stiffening member is of V-corrugated cross-section with strips connected at the apices of the vees.
10. A panel according to claim 6 characterized in that the or each stiffening member is formed with an integral flange at each point of connection with a sheet member.
11. A panel according to claim 10 characterized in that each flange is tapered and has an upper surface and a lower surface, the upper surface being adhered to one of the sheet members and the lower surface lying in a plane inclined to the plane of the upper surface.
12. A panel according to claim 11 characterized in that the mineral fibre reinforcement in the or each stiffening member extends into a flange at a location closer to the lower surface than to the upper surface.
13. A panel according to claim 1 characterized in that voids between the sheet members and the or each elongate stiffening member contain expanded plastics foam material.
14. A panel according to claim 6 characterized in that the or each elongate stiffening member is adhered to the spaced sheet members by an epoxy resin or a toughened acrylic resin.

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